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Coating apparatus

The invention relates to a coating apparatus comprising a housing, means for establishing a vacuum in the housing, a source of coating material mounted in the housing for providing a vapor stream having approximately a cosine distribution, and at least one rotor mounted in the housing for rotation about an axis which is offset from the horizontal by less than 45°, said at least one rotor extending above and below the source and being provided with substrates carrying surfaces overlying the vapor source at least part of the time that the rotor is rotated.

Such a coating apparatus is known from the U.S.-patent 4 034 704. With this apparatus a support is rotated by a central drive shaft extending into a vacuum chamber in sealed relation thereto. The central drive shaft has support arms secured thereto, each carrying a support head. Each support head has several substrate holding plates rotatably mounted thereon and coupled together by a gear train for turning about their axis of rotation. Each support head is rotatable by a respective support head drive shaft coupled to the central drive shaft through gearing and carrying a driving gear forming part of the gear train. In this arrangement the substrate holding plates are downwardly and outwardly inclined to each other. The source, which evaporates and ejects the coating material is mounted in the middle of the bottom of the housing.

Other prior art coating apparatus have substrate supporting means rotating around a vertical axis or a horizontal axis. In the former case, the substrate supporting plates extend horizontally (US—PS 3 991 707) or outwardly and downwardly inclined (US—PS 3 799 110 and Swiss patent 349855). In the latter case the substrates are arranged on the circumference of a squirrel cage, the source of coating material being arranged in the center (DDR-Patent 91174).

Further masking has been used successfully in low defect coating systems. However, this requires frequent clean-up maintenance since the masking in most coating geometries receives more coating vapor than the substrate. The excess coating material builds up on the mask to a point where it can flake off and cause contamination.

It is the aim underlying the invention to provide a coating apparatus for the production of relatively defect-free vacuum coated substrates in a system which permits as many substrates as possible to be loaded in a given size vacuum chamber.

This aim is obtained with the coating apparatus according to the invention which is characterized in that the substrates carrying surfaces are the surfaces of a generally circular rack facing the axis of rotation and in that the projection of the innermost extremity of the top portion of said rack is spaced from the outermost extremity of the bottom portion of the rack.

The coating apparatus according to the invention overcomes the difficulties of the prior art by using a tilted spindle which enjoys freedom from contamination of the vertical axis geometry while still making it possible to carry almost as large a load size as with a horizontal axis geometry. With the coating apparatus according to the invention dirt and other contaminations are minimized, which can fall on the substrate, and a relatively good uniformity in the coating of the substrates is obtained, while the coatings can be applied with very few defects. Further it is possible to readily operate the apparatus in conjunction with a clean room environment.

The described shape of the rack can be obtained, if the rack is defined by the wall of a truncated cone.

The effectiveness of the coating apparatus can be increased by the fact that an additional rotor of substantially the same size and shape as the first named rotor is mounted in said housing and in that the additional rotor is also offset from the horizontal by an angle of less than 45° but in an opposite direction so that the upper extremities of the rotors are in relatively close proximity to each other and the lower extremities of the rotors are spaced apart a substantial distance.

It is convenient, if the source is disposed between the two rotors. Thereby the source can be disposed at a level which is generally in line with the axis of rotation for the rotors.

Additional objects and features of the invention will appear from the following description in which the preferred embodiments are set forth in conjunction with the accompanying drawings.

Fig. 1 is a side elevational view in schematic form of a coating apparatus according to the invention and

Fig. 2 is a top plan view of the coating apparatus shown in Fig. 1.

The coating apparatus as shown in Figures 1 and 2 consists of a housing 11 which has a generally rectangular dimension in front elevation as shown in Figure 1 and a generally barrel-shaped configuration which is shown in Figure 2. As shown, the housing 11 is adapted to rest upon a floor 12 and is provided with a pair of spaced generally parallel vertical end walls 13 and 14, a generally horizontal top wall 16 and front and rear walls 17 and 18. As shown in Figure 2, the front wall 17 can be provided with a pair of loading doors 21 and 22 which are relatively small in size whereas the rear wall 18 can be provided with a large access door 23 to facilitate cleaning of the apparatus.

The apparatus is constructed in such a

manner so that it can be readily mated with clean room facilities. Thus, by way of example, as shown in Figure 2, the apparatus may be mounted in such a manner so that the loading doors 21 and 22 open into a clean room as mentioned above and where the remainder of the apparatus is disposed in a dirty environment (represented by line 26).

Means is provided for supplying a vacuum to the interior of the housing and can consist of one or more diffusion pumps 31 which are connected to the housing to provide the desired vacuum within the housing.

At least one and preferably a pair of rotors 36 and 37 are mounted within the housing 11. Means (not shown) is provided for rotating the rotors 36 and 37 about axes 38 and 39 which are offset from the horizontal by an angle which is less than 45°. As shown, the rotors 36 and 37 are in the form of truncated cones and support structures 41 and 42 which are mounted upon the associated shafts. The support structures 41 and 42 are represented in the form of flat circular plates which carry racks or rack-like structures 43 and 44. The racks 43 and 44 as shown are generally conical but, if desired, can be generally cylindrical to provide generally circular means which are rotated about the axes 38 and 39.

It will be noted that the rotors 36 and 37 are mounted in such a manner so that their upper portions are tipped toward each other whereas the lower portions are tilted away from each other. This has several advantages as hereinafter described. As shown in Figures 1 and 2, it permits the mounting of a source pedestal 46 within the housing between the lower extremities of the two rotors 36 and 37. At least one and preferably two or more coating sources 47 are carried by the pedestal and, as shown in Figure 2, are provided on opposite sides of the center line of the chamber. The sources 47 can be of a conventional type as, for example, electron gun type sources each of which provides a vapor stream which has approximately a cosine distribution. The generally rack-like structures 43 and 44 extend outwardly at an angle to a line normal to the support structures 41 and 42 so that the inner surfaces of the same generally approximate the cosine distribution intensity of the vapor stream from the source or sources 47 carried by the pedestal 46. In this way it is possible to obtain a uniformity distribution within approximately 10% without the use of auxiliary masks to modify the vapor stream distribution.

The interior surfaces 51 and 52 of the racks 43 and 44 can be utilized for supporting articles or substrates 53, one surface of which is to be coated from the materials evaporated from the sources 47. The surfaces 51 and 52 have a length perpendicular to the support structures 41 and 42 and parallel respectively to the axes 38 and 39 which is such that an imaginary vertical line represented by the broken line 54 extending vertically from the topmost portion of the rack 43 readily clears the bottom portion of the rack as shown particularly in Figure 1 with the rack inclined to the amount shown for the purpose hereinafter described.

In addition, there should be sufficient space provided between the top extremities or portions of the rotors 36 and 37 so some vapor can escape therethrough and be monitored by the optical monitoring apparatus 56 carried by the top of the housing 11.

It should be appreciated that the source pedestal 46 is also an appropriate place to mount glow discharge devices which are frequently used for cleaning of the surfaces to be coated. Also, if heating is required, heaters can also be mounted on the source pedestal 46. The glow discharge system and the heaters should be mounted in such a manner that they would face downwardly so they will not collect dirt or other debris during operation of the apparatus. These glow discharge devices and heaters are represented schematically at 58 and 59 on the source pedestal.

In order to facilitate cleaning out the interior of the housing 11, shields 61 and 62 can be provided in the housing above the rotors 36 and 37. As will be noted, the shields 61 and 62 are spaced apart so that there is provided a central opening 63 to make it possible for the optical monitoring apparatus 56 to monitor the vapor streams from the sources 47. The dimensions of the racks 43 and 44 are primarily determined by the size of substrates which it is desired to coat. By way of example, a coating apparatus incorporating the present invention could be provided with a housing having an overall height of approximately 2,7 m with the rotors having a diameter of 2,7 m and with the racks 43 and 44 being capable of carrying substrates up to approximately 120 cm^2.

Operation of the coating apparatus in performing the method may now be briefly described as follows: Let it be assumed that it is desired to operate the apparatus in a clean room environment as shown. When such is the case, the loading doors 21 and 22 are opened and the racks are loaded with the substrates which are to be coated. The coating sources 47 are supplied with material after which the loading doors 21 and 22 are closed. The rotors 36 and 37 are then rotated about the axes 38 and 39. If desired, glow discharge cleaning and heating steps hereinbefore described can be performed. Thereafter, the sources 47 are placed in operation to cause vapor streams to be formed which will move upwardly in a cosine distribution toward the upper portions of the racks 43 and 44 and to impinge upon the inner surfaces of the substrates 53 carried by the racks and facing the sources 47. In this way, the exposed surfaces of the substrates can be coated with one or more coatings in a manner well known to those skilled in the art. After the coating operation has been completed, the

loading doors 21 and 22 can be opened and the coated substrates unloaded from the rotors 36 and 37. Thereafter, the same procedure can be repeated. The construction of the coating apparatus is such that after numerous coating operations have been carried out, access to the same can be obtained through the large access door 18 in the dirty environment.

It should be noted that the source pedestal 46 is formed so that the sources 47 are mounted at a height which is approximately at the axes of rotation for the rotors 36 and 37 to obtain the most optimum utilization of the coating material. If the electron guns are positioned substantially above the center line, it is difficult to obtain good uniformity. If they are positioned substantially below the center lines, then there is a greater waste of the coating material.

With the construction which is shown, it can be seen that in the event any material falls off the inner surfaces 51 and 52 or off of the substrates carried thereby from the upper portions of the rotors 36 and 37 that the same will drop downwardly and will clear the lower extremities of the rotor and thus will not fall upon the substrates carried by the lower portions of the rotors 36 and 37. This ensures that the surfaces to be coated will remain relatively clean at all times and facilitates the making of coatings which are substantially pin hole free. Thus, it can be seen that tilting of the rotors in the manner hereinbefore described ensures that dirt and other debris falling from the upper portions of the rotors will not fall by force of gravity upon the surfaces of the substrates below. Rather, any material which falls will fall downwardly clear of the rotors onto the bottom of the housing 11.

Claims

1. Coating apparatus comprising a housing (11), means (31) for establishing a vacuum in the housing (11), a source (47) of coating material mounted in the housing (11) for providing a vapor stream having approximately a cosine distribution, and at least one rotor (36) mounted in the housing (11) for rotation about an axis (38) which is offset from the horizontal by less than 45°, said at least one rotor (36) extending above and below the source (47) and being provided with substrates (53) carrying surfaces (51) overlying the vapor source (47) at least part of the time that the rotor (36) is rotated, characterized in that the substrates (53) carrying surfaces (51) are the surfaces of a generally circular rack (43) facing the axis (38) of rotation and in that the projection (54) of the innermost extremity of the top portion of said rack (43) is spaced from the outermost extremity of the bottom portion of the rack (43).

2. Coating apparatus according to claim 1, characterized in that the rack (43) is defined by the wall of a truncated cone.

3. Coating apparatus according to claim 1 or 2, characterized in that an additional rotor (37) of substantially the same size and shape as the first named rotor (36) is mounted in said housing (11) and in that the additional rotor (37) is also offset from the horizontal by an angle of less than 45° but in an opposite direction so that the upper extremities of the rotors (36, 37) are in relatively close proximity to each other and the lower extremities of the rotors (36, 37) are spaced apart a substantial distance.

4. Coating apparatus according to claim 3, characterized in that the source (47) is disposed between the two rotors (36, 37).

5. Coating apparatus according to claim 4, characterized in that the source (47) is disposed at a level which is generally in line with the axis of rotation (38, 39) for the rotors (36, 37).

Revendications

1. Appareil de revêtement comprenant une enceinte (11), des moyens (31) destinés à établir une dépression dans l'enceinte (11), une source (47) de matière de revêtement montée dans l'enceinte (11) pour fournir un courant de vapeur ayant approximativement une distribution cosinusoïdale, et au moins un rotor (36) monté dans l'enceinte (11) afin de tourner autour d'un axe (38) qui est décalé de l'horizontale de moins de 45°, ledit rotor (36) s'étendant au-dessus et au-dessous de la source (47) et présentant des surfaces (51) portant des substrats (53) s'étendant au-dessus de la source (47) de vapeur pendant au moins une partie du temps de rotation du rotor (36), caractérisé en ce que les surfaces (51) portant les substrats (53) sont les surfaces d'un râtelier sensiblement circulaire (43) tourné vers l'axe (38) de rotation, et en ce que la saillie (54) de l'extrémité intérieure de la partie supérieure dudit râtelier (43) est espacée de l'extrémité extérieure de la partie inférieure de râtelier (43).

2. Appareil de revêtement selon la revendication 1, caractérisé en ce que le râtelier (43) est défini par la paroi d'un cône tronqué.

3. Appareil de revêtement selon la revendication 1 ou 2, caractérisé en ce qu'un rotor supplémentaire (37) de sensiblement la même dimension et la même forme que le premier rotor cité (36) est monté dans ladite enceinte (11) et en ce que le rotor supplémentaire (37) est également décalé de l'horizontale d'un angle de moins de 45°, mais dans une direction opposée, afin que les extrémités supérieures des rotors (36, 37) soient relativement proches l'une de l'autre et que les extrémités inférieures des rotors (36, 37) soient espacées d'une distance substantielle.

4. Appareil de revêtement selon la revendication 3, caractérisé en ce que la source (47) est disposée entre les deux rotors (36, 37).

5. Appareil de revêtement selon la revendication 4, caractérisé en ce que la source (47) est disposée à un niveau qui est généralement en

alignement sur l'axe de rotation (38, 39) des rotors (36, 37).

Patentansprüche

1. Beschichtungsvorrichtung mit einem Gehäuse (11), mit Einrichtungen (31) zur Ausbildung eines Vakuums in dem Gehäuse (11), mit einer Quelle (47) für Beschichtungsmaterial, die in dem Gehäuse (11) angebracht ist und zur Erzeugung eines Dampfstroms dient, der annähernd eine Kosinusverteilung hat, und mit wenigstens einem Rotor (36), der in dem Gehäuse (11) für eine Rotation um eine Achse (38) angeordnet ist, die zur Horizontalen um weniger als 45° versetzt ist, wobei sich wenigstens ein Rotor (36) über und unter die Quelle (47) erstreckt und mit Substraten (53) versehen ist, welche Oberflächen (51) tragen, die wenigstens für einen Teil der Zeit, während der der Rotor (36) gedreht wird, über der Dampfquelle (47) liegen, dadurch gekennzeichnet, daß die die Substrate (53) tragenden Oberflächen (51) die Oberflächen eines insgesamt kreisförmigen Rahmens (43) sind, der der Rotationsachse (38) zugewandt ist, und daß der Vorsprung (54) des ganz innen liegenden Endes des oberen Abschnitts des Rahmens (43) im Abstand vom ganz außen liegenden Ende des unteren Abschnitts des Rahmens (43) angeordnet ist.

2. Beschichtungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Rahmen (43) von der Wand eines Kegelstumpfs gebildet wird.

3. Beschichtungsvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß ein zusätzlicher Rotor (37) von im wesentlichen der gleichen Größe und Form wie der erstgenannte Rotor (36) in dem Gehäuse (11) angeordnet ist und daß der zusätzliche Rotor (37) ebenfalls aus der Horizontalen um einen Winkel von weniger als 45°, jedoch in einer entgegengesetzten Richtung versetzt ist, so daß die oberen Enden der Rotore (36, 37) sich in relativ geringer Nähe beieinander befinden, während die unteren Enden der Rotore (36, 37) einen wesentlichen Abstand zueinander haben.

4. Beschichtungsvorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Quelle (47) zwischen den beiden Rotoren (36, 37) angeordnet ist.

5. Beschichtungsvorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die Quelle (47) auf einer Höhe angeordnet ist, die insgesamt in Linie mit der Drehachse (38, 39) für die Rotore (36, 37) liegt.

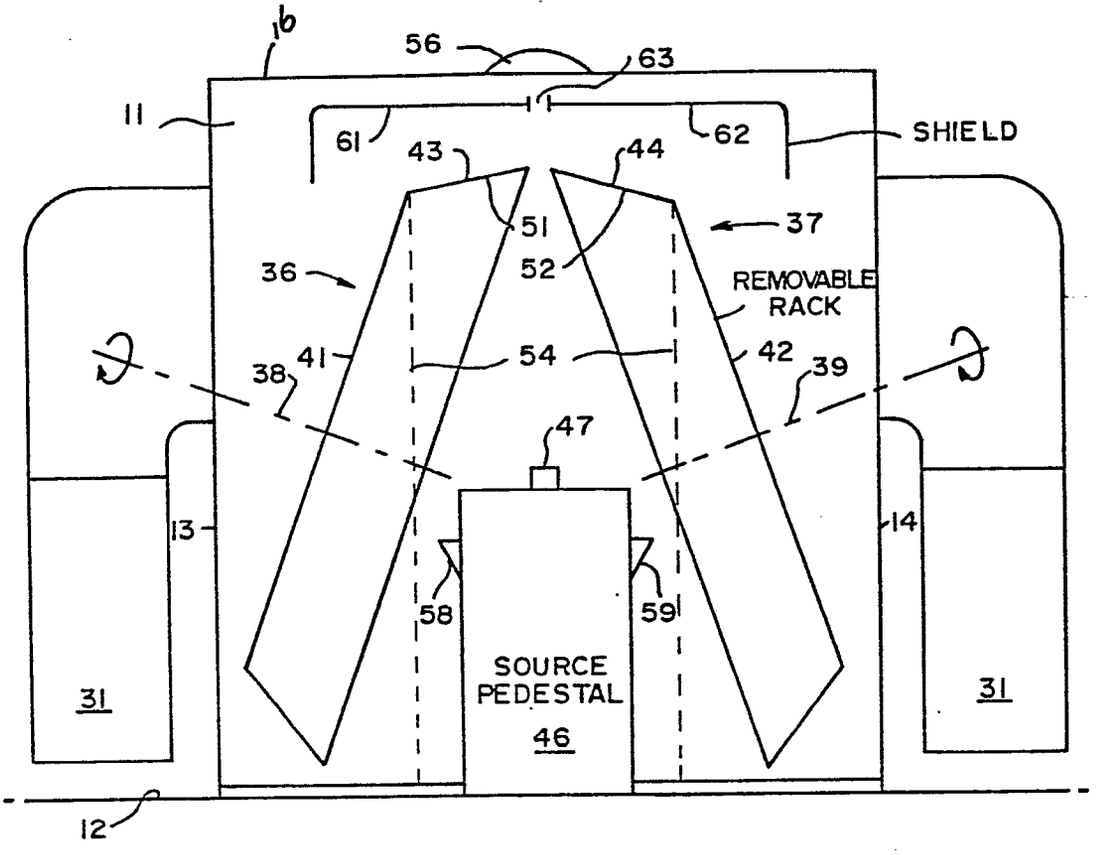
16
56
63
11
61
62
SHIELD
43
44
51
37
52
36
REMOVABLE RACK
41
54
42
38
39
47
13
14
58
59
SOURCE PEDESTAL
46
31
31
12

FIG.—1

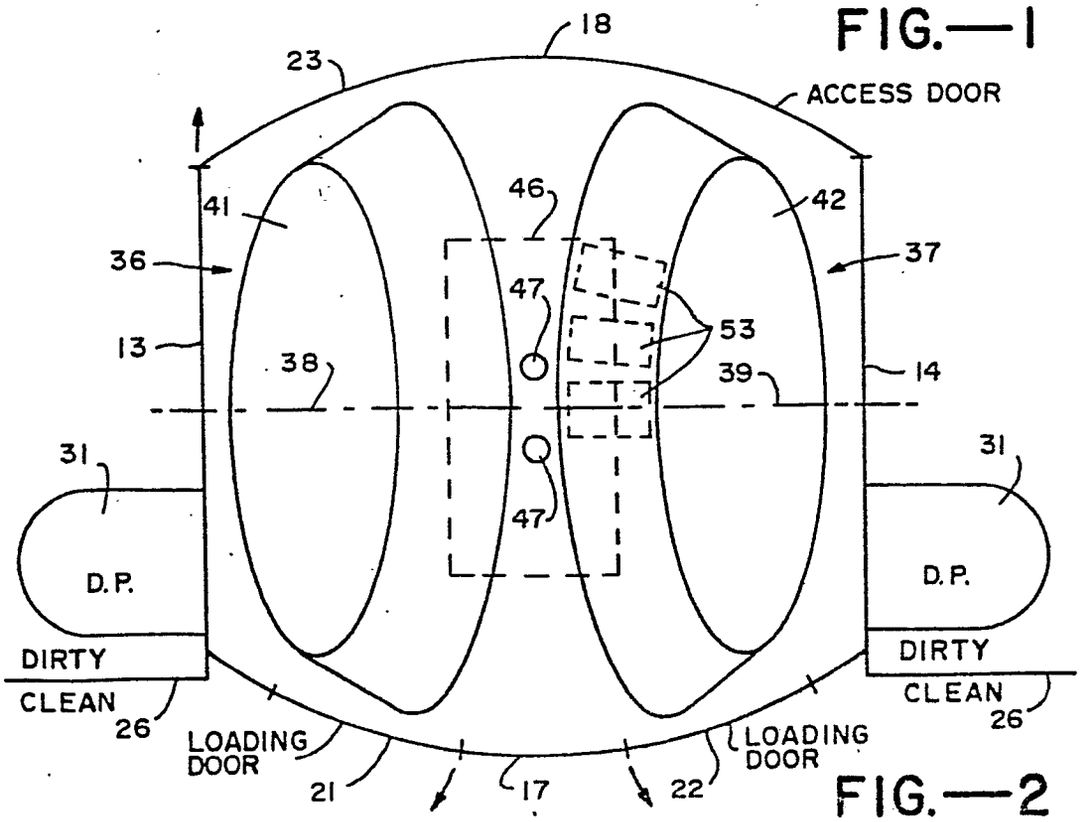
18
23
ACCESS DOOR
41
46
42
36
37
47
53
13
38
39
14
31
31
47
D.P.
D.P.
DIRTY
CLEAN
DIRTY
CLEAN
26
26
LOADING DOOR
LOADING DOOR
21
17
22

FIG.—2